

HDMI Developers Conference



Agilent Technologies



HDMI V1.3b

Agilent Compliance Test solution

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Purpose and Agenda



• Purpose

- Overview of latest HDMI test method and understanding of measurement solutions

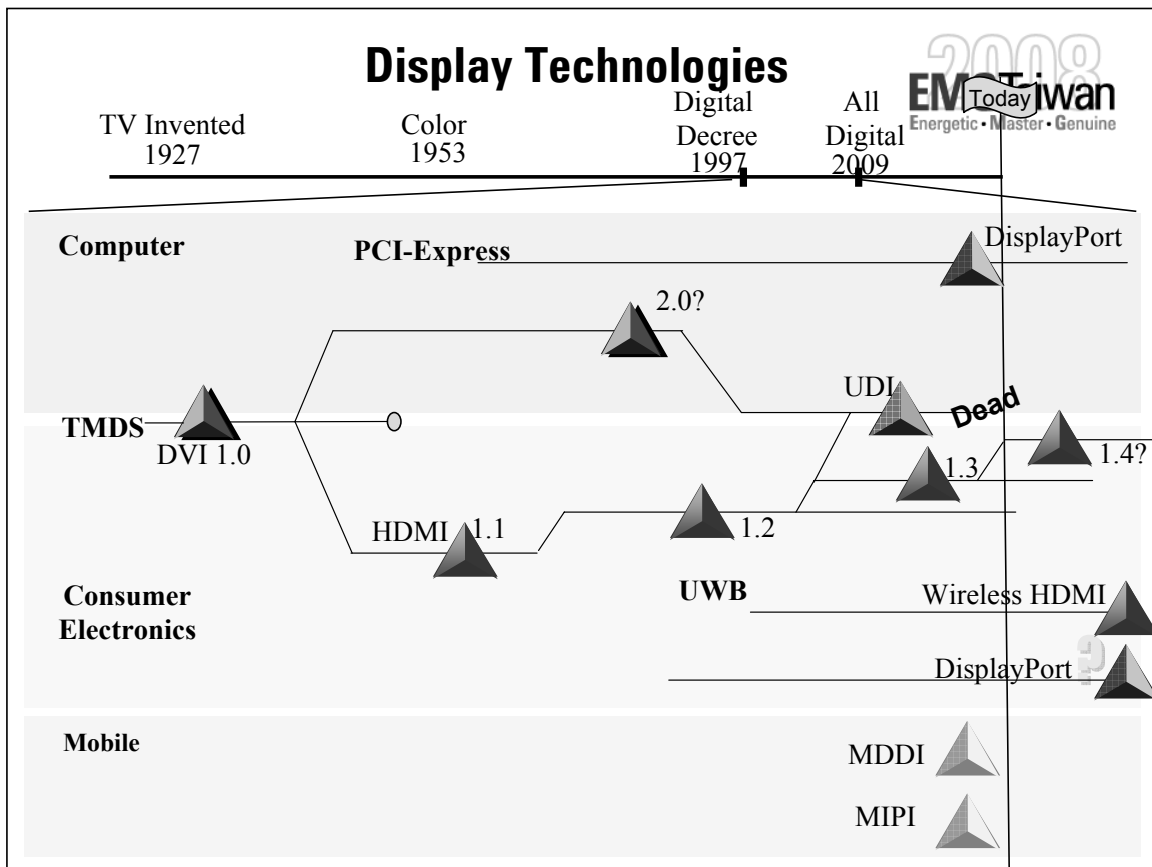
• Agenda

- HDMI overview
- HDMI Sink and Source Compliance test
- HDMI compliance testing policies



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HDMI Specification Overview

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HDMI Spec 1.3a

- Is developed by 7 companies including HDMI Founder(December 2002 HDMI 1.0)
- Extend CE/AV device-oriented capabilities based on DVI specification
- Mandate compliance test and introduce mark certification
- Use ATC to perform CTS-based product certification

- Actual standard interface used by Audio/Video
 - Increasing number of adopters (Over 800 companies as of May 2008)
 - Installed in both high end devices and low cost devices
- Installed in the devices except TV/DVD players
 - Camera/recorder, digital camera(still picture), game playing device, and etc.
- Expand from CE to PC market
 - PC with multimedia capability
 - PC display with HDMI interface

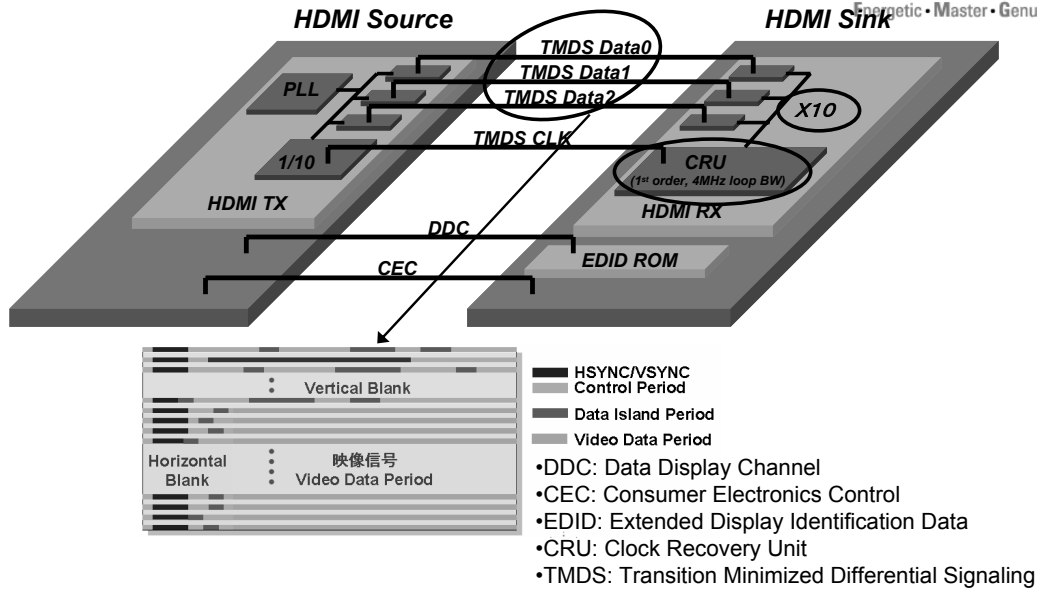
HDMI Compliance Test Specification ver. 1.3C

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HDMI Overview

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Use 3 wires to transfer picture and audio signals

→ Transfer speed increases in proportion to resolution and hue

In HDMI 1.3a, maximum (transfer) speed of 1 wire is 3.4Gb/s

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HDMI Sink and Source Compliance test

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Authorized Test Center commitments to Agilent HDMI 1.3 Solution!!!

HDMI 1.2



6 Months Ago

★ Competitor Installations



NOW !!!

★ Panasonic(Japan): has Agilent Tx solution. Committed to Tek for Sink Test

★ Sony(Japan), SI(Shinzen, Shanghai, Germany, Sunnyvale), Philips(France)

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HDMI – Sink Test Cases

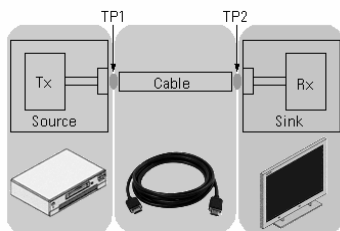
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• High-Speed Electrical Tests:

- 8-5 Min. Differential Sensitivity
- 8-6 Intra-Pair Skew
- 8-7 Jitter tolerance
- 8-8 Differential Impedance

TMD5 Signal Generator

Sampling Scope + TDR



• Protocol Tests:

- | | | |
|--------|------|------|
| • 8-15 | 8-16 | 8-17 |
| • 8-20 | 8-21 | 8-18 |
| • 8-22 | 8-23 | 8-19 |
| • 8-24 | 8-25 | |

TMD5 Signal Generator,
N5998A PAG,
Quantum Data 882CA

Low-Speed Electrical Tests

- 8-4 Term Voltage
- 8-9 DDC/CEC line C
- 8-10 HPD output V
- 8-11 HPD output R
- 8-12 +5V power max current
- 8-13 CEC line connectivity
- 8-14 CEC line degradation

Volt-, Multi-, LCR-Meter

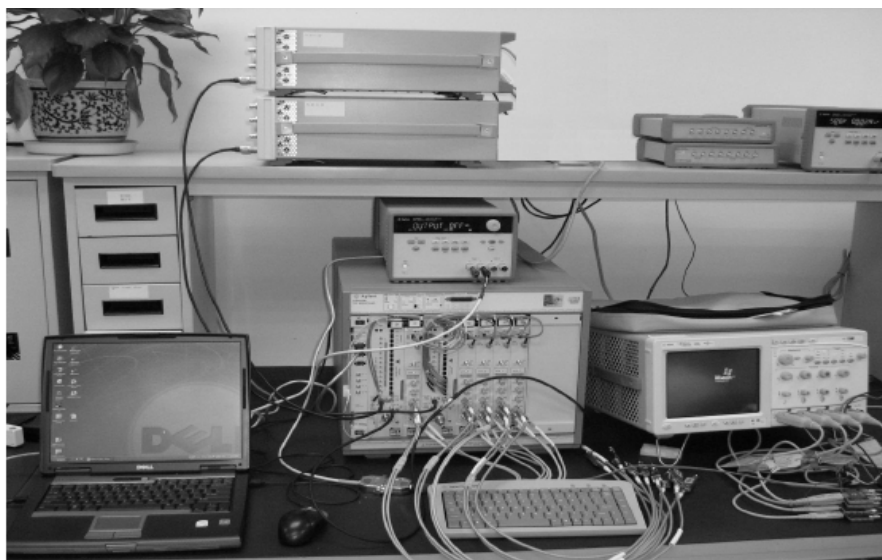


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HDMI Compliance solution In ATC

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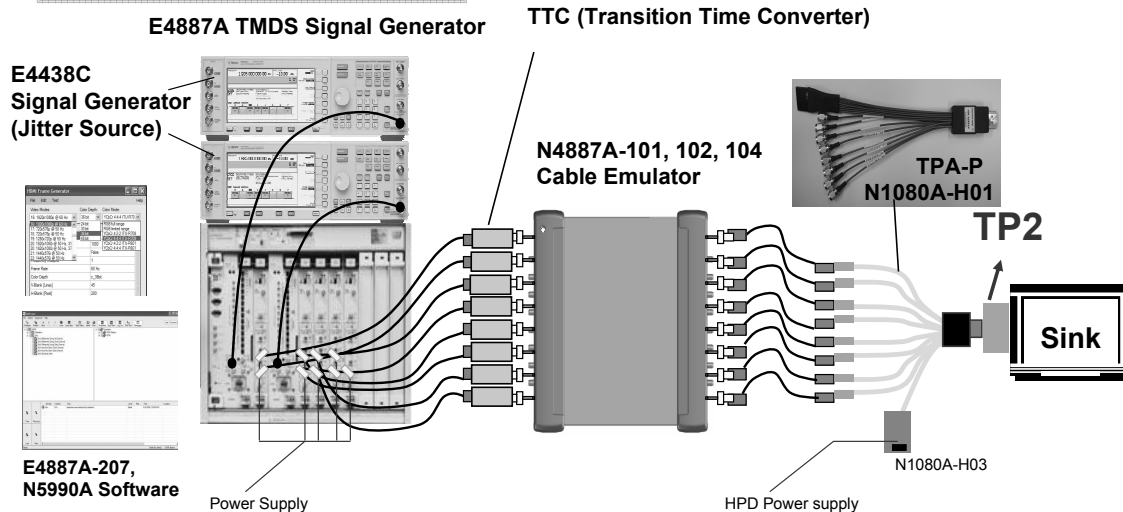
Physical layer measurement of sink device

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- Basic thoughts

- Set input of sink device to worst case (amplitude, skew, jitter) and judge whether there is picture noise (pixel error)

Jitter tolerance test case

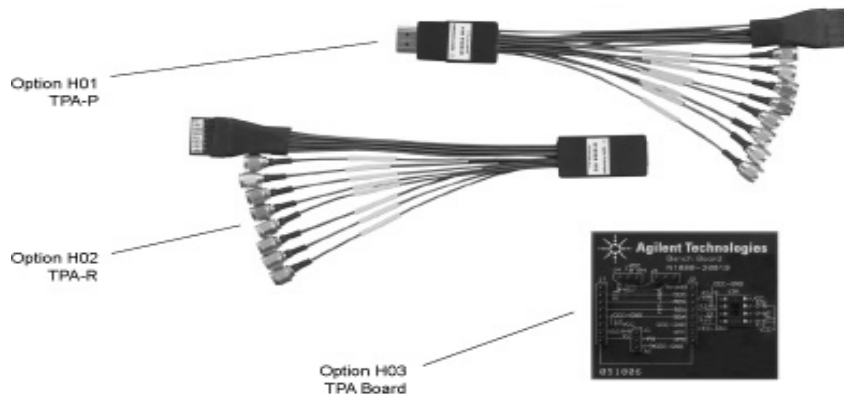


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N1080A Test Access Fixture

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- High Performance Test Point Access Adapters

- TPA-P: N1080A H01 (plug)
- TPA-R: N1080A H02 (receptacle)

- Low Frequency Test Board: N1080A H03

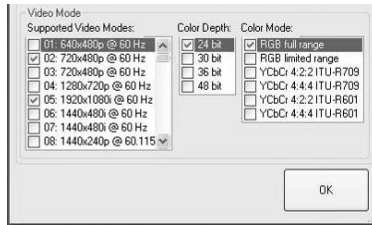
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Sink measurement: Automatic measurement software

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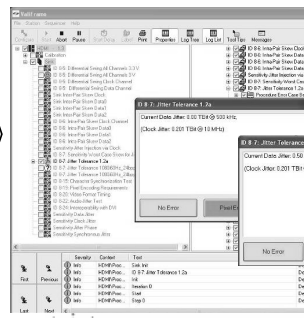
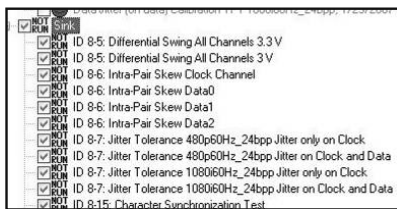
Specify supported format



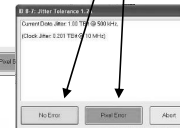
- DUT can select supported format and automatically display necessary test items
- Checkbox can be used to simply select test items
- Compliance mode meeting CTS standard and Expert mode to perform more detailed resolution and debugging is provided

Execution of test

Selection of test items



Observe DUT display to judge whether there is error



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Software for TMDS generator N4998A-207 HDMI Frame Generator

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CEA861 format select window

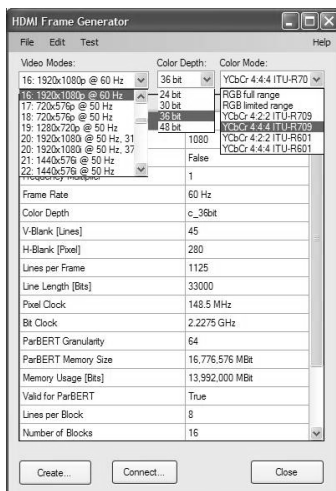
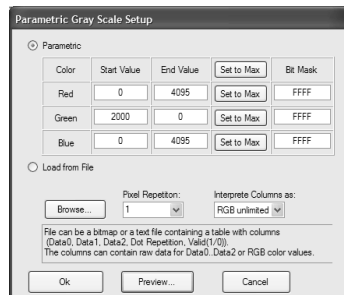
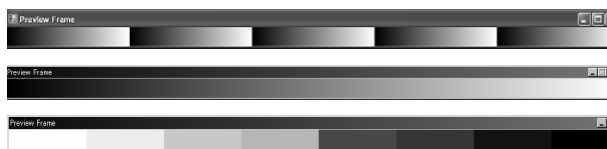
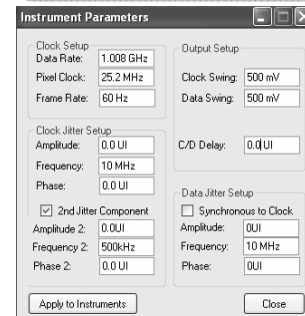


Image data edition window



clock rate, signal amplitude, jitter frequency/amplitude change



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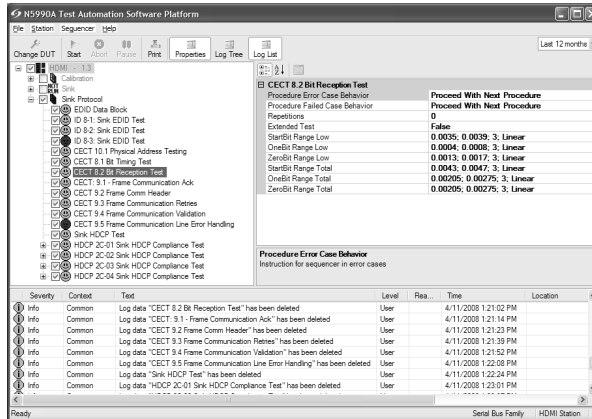
Quantum Data 882E Support

Highest Test Integration



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- Integrates mandatory EDID, CEC and HDCP tests in test automation
- **Quantum Data 882 is the leading instrument, abundant in test labs; complementary to PAG N5998A and E4887A TMDs Signal Generator**
- **Consolidated sink, source and protocol test results in joint Excel report**
- Public announcement Apr. 14, at HDMI (CEA 861) Plugfest in Milpitas



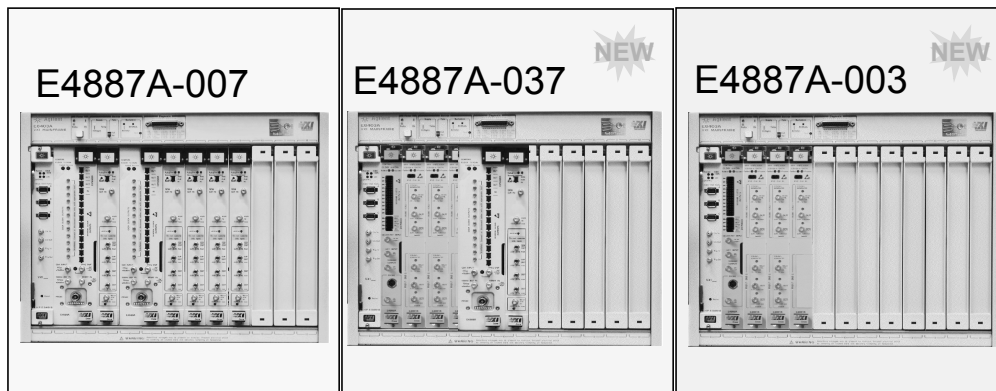
- N5990A opt. 351
- CPL May 1
- SHP June 30, 2008

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Product Briefing for new HDMI Platform

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Upgrade:
Add 1x E4809A+ 4x N4874A **Upgrade:**
Add 1x E4809A+ 1x N4874A

Upgradable for Display port and MIPI



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Change in CTS 1.3b Sink device test

- Measurement data rate can be increased to 3.4Gb/s (the measurement can be performed at maximum rate supported by the device)
- Change in Test ID 8-7 Jitter Tolerance test
 - Usage of TTC (Transition Time Converter)
 - Definition of cable emulator with data rate more than 742.5Mb/s (Type 1 and Type 3)
 - Addition of jitter test of TMDS data channel (which is limited to clock only)
- Change in test methods and judgment conditions with specification change
 - Common mode voltage of Test ID 8-5, judgment conditions of 8-6, judgment conditions of 8-8
- Addition of deep color feature test



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Change in CTS 1.3b jitter tolerance test

The measurement rate and the type of TTC (Transition Time Converter) cable emulator are clarified

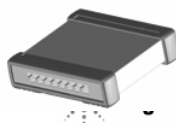
Typical (MHz)	Low (MHz)	High (MHz)	TTC (MHz)	1 st Cable Emulator	2 nd Cable Emulator
27	>=25	<=27.1	74.25	Type 1 Cat1 + Cat2	Type 2 27MHz (JAE)
74.25	>=27.1	<=74.25	74.25	Type 1 Cat1	Type 2 75MHz (JAE)
148.5	>74.25	<=165	148.5	Type 1 Cat2	Type 3
222.75	>165	<=222.75	222.75	Type 1 Cat2	Type 3
340	>222.75	<=340	340	Type 1 Cat2	Type 3

TTC will use TTC with equivalent rise time of TP1 mask for each rate on Data channels (6 in total)

TTC: Picosecond Labs'
5915-110-xxxPS



Type 1 Cable Emulator
Agilent E4887A-101 Cat1
Agilent E4887A-102 Cat2



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Type 3 Cable Emulator
Agilent E4887A-103
Or Agilent E4887A-104



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New types of cable emulators (Type1, Type3)

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- The thoughts of cable emulator
 - Use cable meeting the specification to emulate waveform degradation in worst case
- Add 2 cable emulators
 - Type 1
 - Is used to emulate standard cable. ISI jitter plays a dominating role
 - Corresponds to Cat 1 (less than 742.5Mb/s rate) and Cat 2 (more than 742.5Mb/s rate) cables
 - Type 3
 - Is used to emulate cables with built-in passive equalizer. The attenuation of waveform amplitude is larger while ISI is smaller.
 - Only define Cat 2 (more than 742.5Mb/s rate)
- Reference:
 - Type 2 is cable emulator with 270Mb/s and 742.5Mb/s rate used in the versions no higher than CTS 1.2a



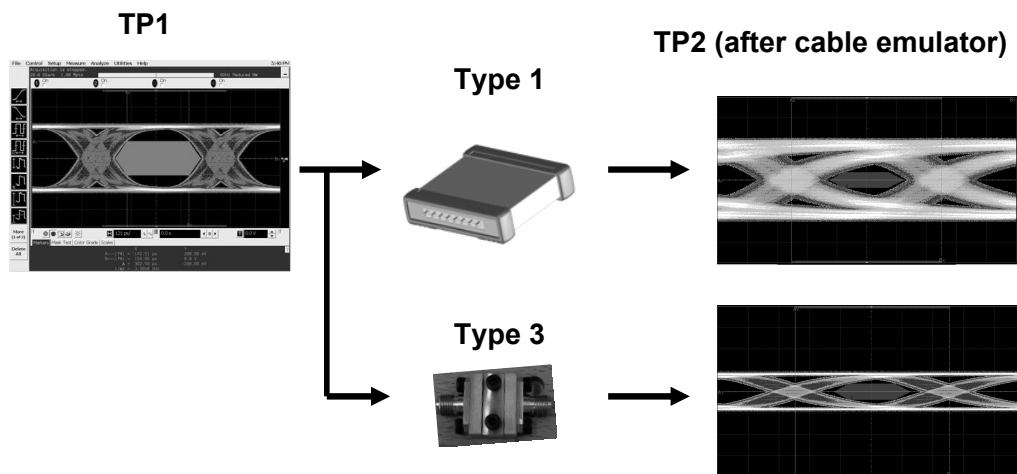
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Features of cable emulator

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1.65Gb/s waveform case



Type 1 and Type 3 cable emulator
can be provided only by Agilent



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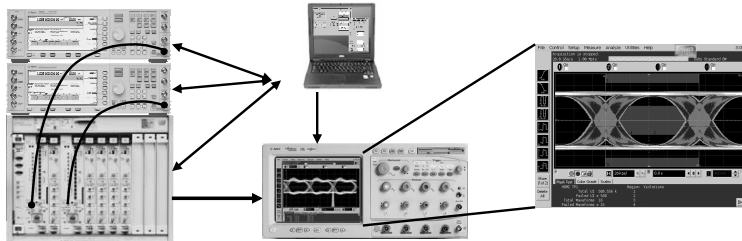
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Sink measurement: Automated jitter adjustment

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Use N5990A automated measurement software to automatically adjust the amount of jitter (compliant with TP1 mask)

- Completely automated (it can automatically judge whether to comply with mask)
- Use jitter addition performance with good linearity to provide high speed adaptability
- The adjustment of jitter which took several hours previously can be completed in about 15 minutes now



Use automated measurement software to control both jitter and oscilloscope to match waveform with TP1

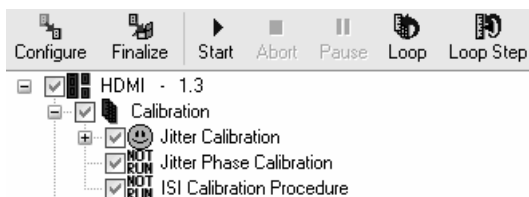
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Jitter Tolerance Automation tool

Jitter Calibration Routines

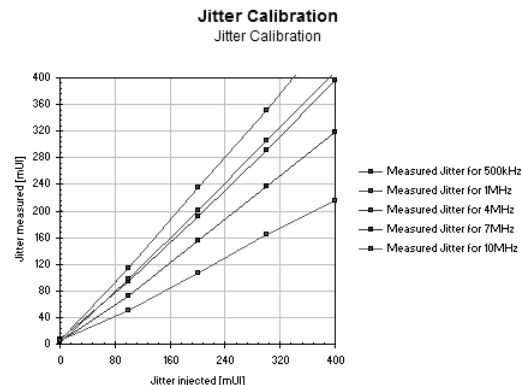
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Automated, fast calibration of:

- ✓ Jitter Amplitude
- ✓ Jitter Phase
- ✓ ISI

- ✓ Jitter Calibration is done once for ALL measurements
- ✓ Individual Cal routines can be repeated
=> Enables fast calibration
~15 min
- ✓ Cal Results are documented
=> Traceability
- ✓ Efficient equipment control
=> highest result accuracy



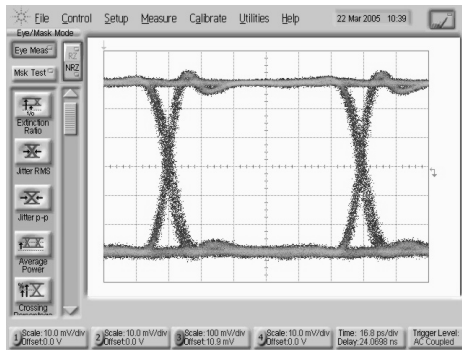
Total calibration time: ~ 15 min!!

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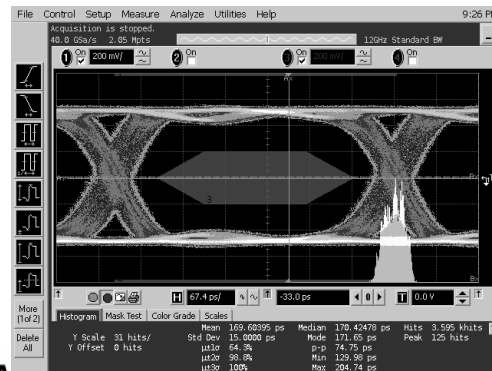
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Excellent Signal Performance up to 7G Example Eye Diagrams at 2.2275 Gb/s

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- ParBERT's leading low intrinsic jitter (9 ps pp) and fast transitions (20 ps)
- Independent control of timing and voltage per channel
- Controlled specific jitter can be injected separately for clock and data



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Sink test equipment requirement

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- TMD5 Data signal characteristics:
 - Data Eye shape
 - Rise time, fall time can be changed to match slope of TP1 eye diagram at following test frequencies: 27MHz, 74.25MHz, 148.5MHz, 165MHz, 222.75MHz, 340MHz. This may require addition of a transition time converter.
 - Overshoot $\leq 10\%$ of differential 1Vp-p swing.
 - Undershoot $\leq 10\%$ of differential 1Vp-p swing.
 - Intrinsic TMD5_DATA Jitter no greater than 0.15 Tbit

$$\text{If Pixel Rate} = 340\text{MHz}, T_{\text{Bit}} = 284\text{ps} \quad 0.15T_{\text{Bit}} = 44.1\text{ps}$$

Table 34. Parameters for N4874A ParBERT 7 Gb/s generator

Addressable technologies	LVDS, CML PECL - 3.3 V; ECL (terminated to 1.3 V/0 V/-2 V) low voltage CMOS, LVDS, CML
Transition times (20% - 80%)	< 20 ps
Jitter	9 ps peak-peak typ. (3)
Cross-point adjustment	20%...80% typ.

Data Pattern (PRBS pattern 2¹⁵-1)

Total Jitter –

DTG5078: at 750 Mb/s

<18 ps_{RMS}, <85 ps_{pk-pk} (typical) with DTGM21,
0.8 V_{pk-pk} delay: 0.0 ns).

DTG5274: at 2.7 Gb/s

<16 ps_{RMS}, <60 ps_{pk-pk} (typical) with DTGM30,
0.8 V_{pk-pk} delay: 0.0 ns).

<14 ps_{RMS}, <60 ps_{pk-pk} (typical) with DTGM31,
0.8 V_{pk-pk} delay: 0.0 ns).

DTG5334: at 3.35 Gb/s.

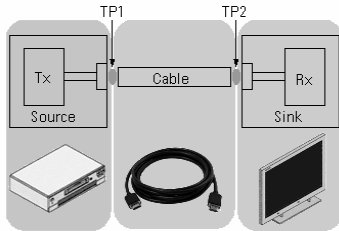
<13 ps_{RMS}, 50 ps_{pk-pk} (typical) with DTGM30 and
DTGM31, 0.8 V_{pk-pk} delay: 0.0 ns).



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Source Test Cases



• High-Speed Electrical Tests (TMDS Tests):

- 7-2 Low voltage
- 7-4 Rise & fall times
- 7-5 Over/undershoot
- 7-6 Inter-pair skew
- 7-7 Intra-pair skew
- 7-8 Clock duty cycle
- 7-9 Clock jitter
- 7-10 Data eye diagram

Real-Time
Oscilloscope

• Protocol Tests:

- 7-16 – 7-37
(with the exc. of 7-20 – 7-22)

N5998A
PAG

• Low-Speed Electrical Tests:

- 7-3 Off voltage
- 7-11 +5V power
- 7-12 Hot plug detect
- 7-13 DDC/DCD Capacity & Voltage
- 7-14 CEC line connectivity
- 7-15 CEC line degradation

Volt-, Multi-,
LCR-Meter

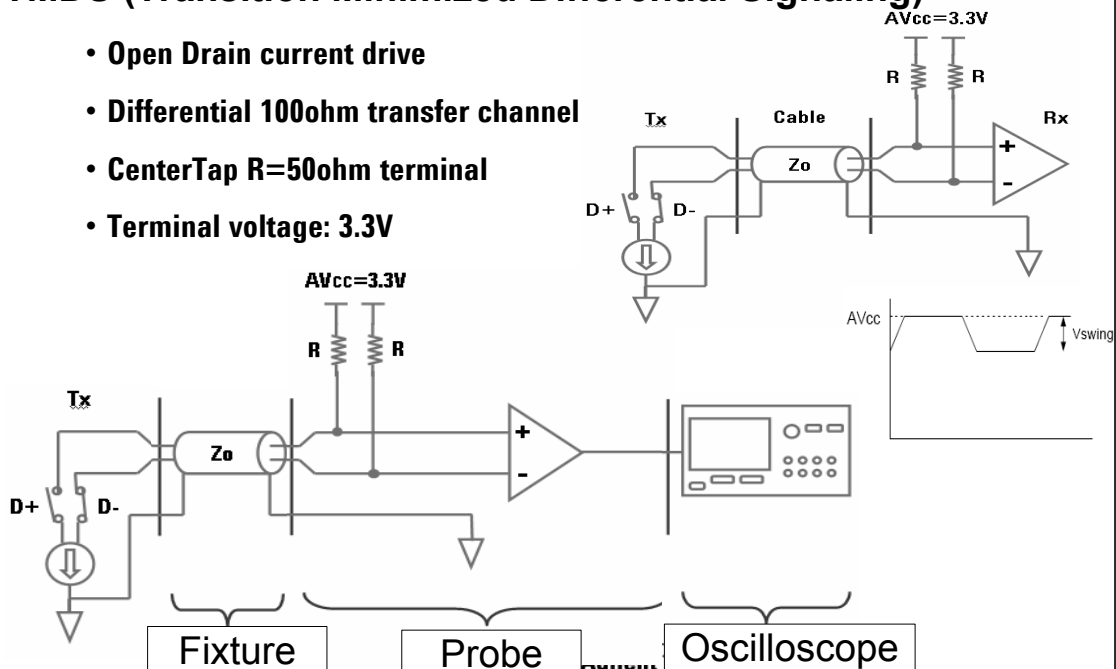


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HDMI transfer channel and measurement system

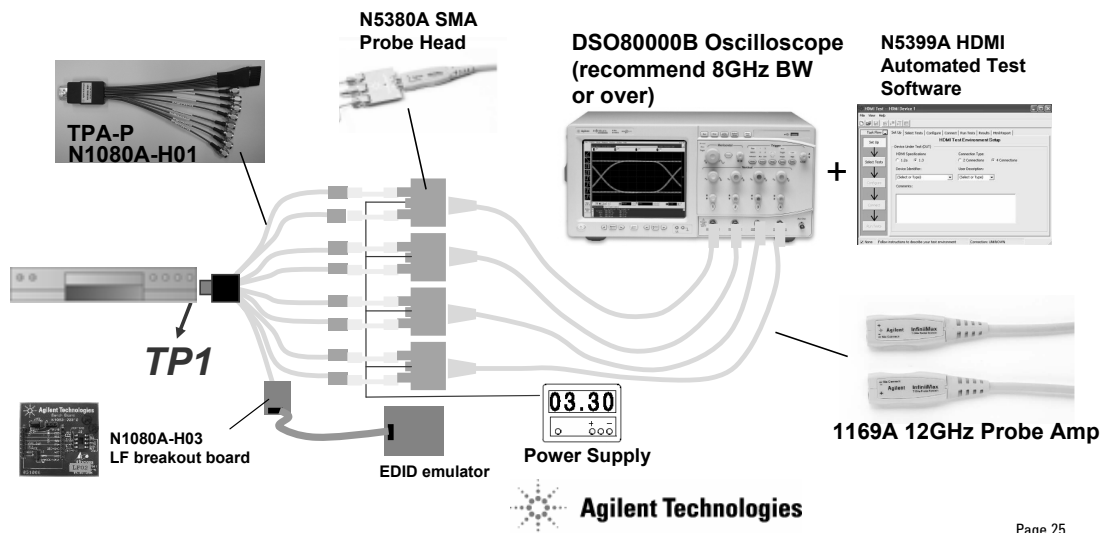
TMDS (Transition Minimized Differential Signaling)

- Open Drain current drive
- Differential 100ohm transfer channel
- CenterTap R=50ohm terminal
- Terminal voltage: 3.3V



Physical layer measurement of Source device

- Basic thoughts
 - Use output TP1 of source device, specified fixture and the oscilloscope to perform measurement



Setup or Session Screen

User Setup

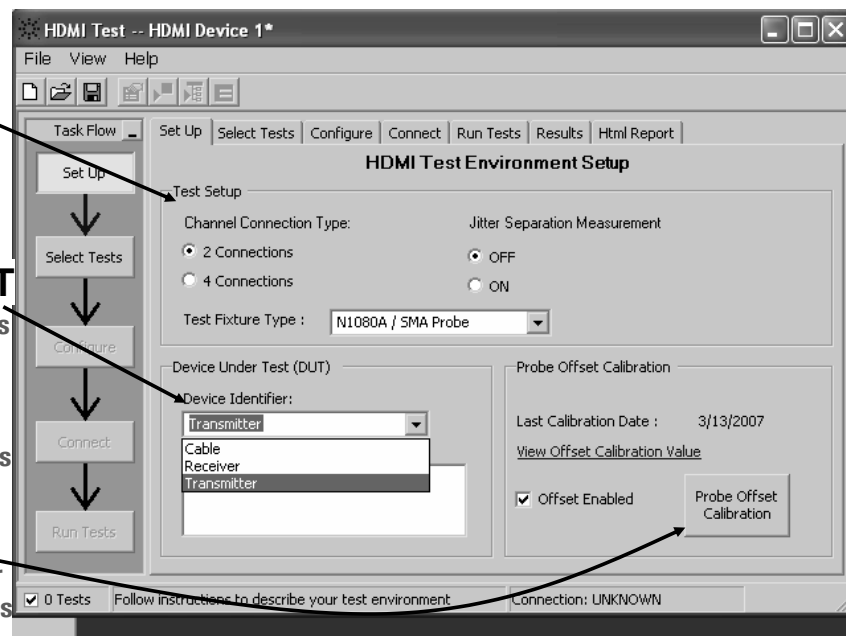
All 4 channels
minimizes
re-connect time

Targeted DUT

Cable and Sink as
well as Source.
RUI for N5990A
New tests and
capability such as
equalization

System Cal

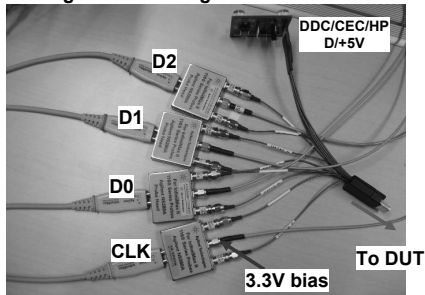
Convenient UI for
calibrating probes
for best accuracy



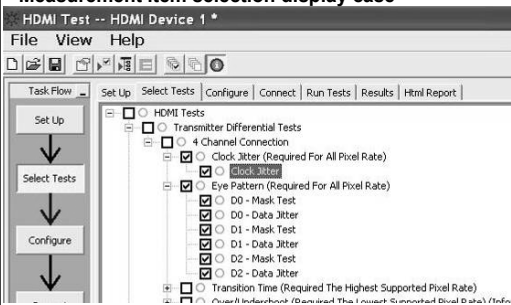
Source waveform measurement: automatic measurement software (N5399A)

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The case of probe and fixture connection used when performing differential signal measurement

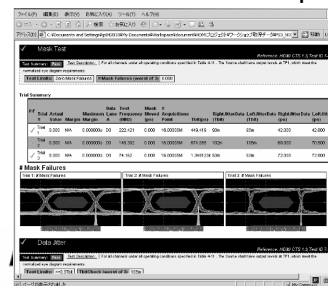


N5399A HDMI Scope Tool
Measurement item selection display case



- By using probe 4ch to perform automatic and continuous measurement, it can provide effective measurement results
- It only needs less than 20 minutes for one measurement rate (it needs about 8 minutes for differential signal measurement and about 10 minutes for single-ended measurement)
- It can perform automatic and continuous measurement on each measurement item of differential signal without needing to change and reconnect probe and fixture

HTML format of measurement report



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Change in CTS 1.3b source test

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- The measurement data rate is increased to 3.4Gb/s (The measurement can be performed at maximum rate supported by the device)
- The bandwidth required for oscilloscope: 8GHz
- Judgment standard changes as the specification changes
 - Change in TP1 eye mask shape, mitigation in VL judgment conditions
- Add communication protocol test of HDMI 1.3 extension capabilities
 - Communication protocol test like Deep Color, xvYCC, High Bitrate Audio and one bit Audio.

DSO8000B Series Oscilloscope



N5998A Protocol Analyzer Generator



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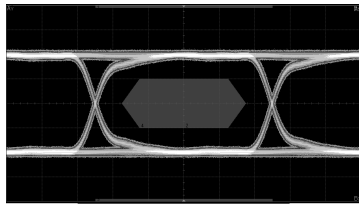
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The effect of oscilloscope bandwidth

1080p 8bit (1.485Gb/s) case

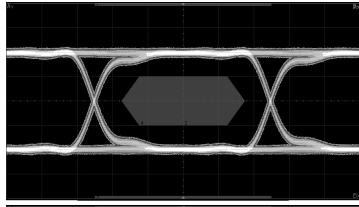
Tr/Tf (20-80%)
measurement
result

8GHz BW



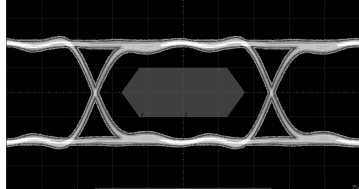
Tr = 77.2ps
Tf = 76.8ps

6GHz BW



Tr = 83.0ps
Tf = 83.6ps

4GHz BW



Tr = 96.0ps
Tf = 96.5ps

- Even the waveforms with 1.485Gb/s and less rise time signals need 8GHz bandwidth
- In HDMI, minimum Tr/Tf value is specified to be 75ps. Recently, there is some case that IC transmitting signals at high speed is designed with limit value
- In this case, 4GHz bandwidth provides correct waveform, and Tr/Tf can't be measured



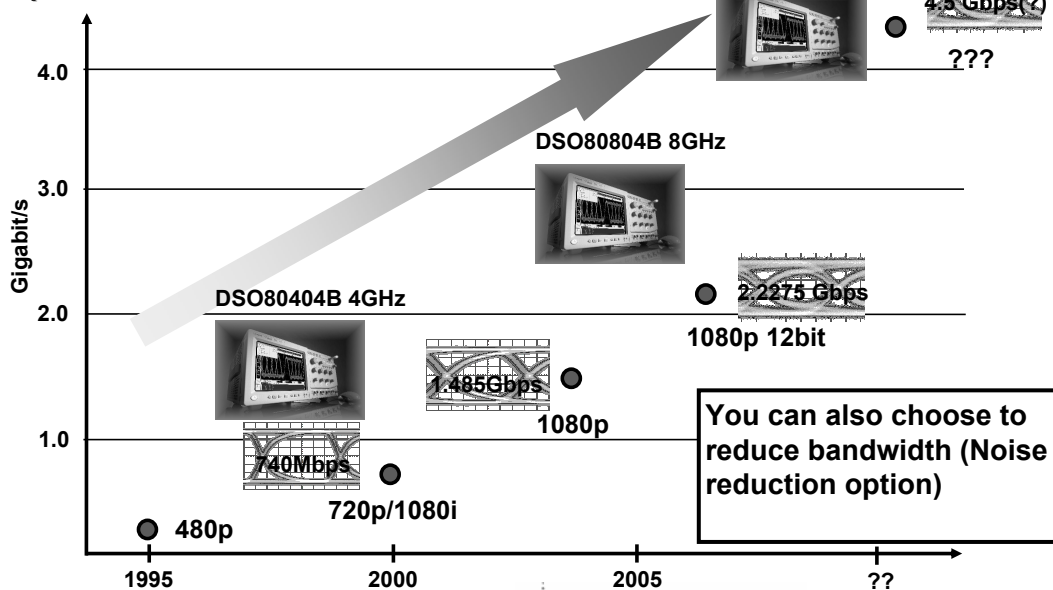
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The bandwidth can be expanded when matched with transfer rate

HDMI = Measurable transfer rate

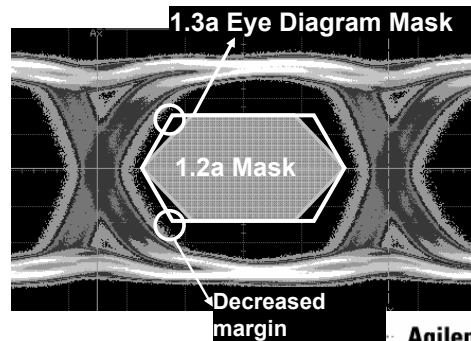
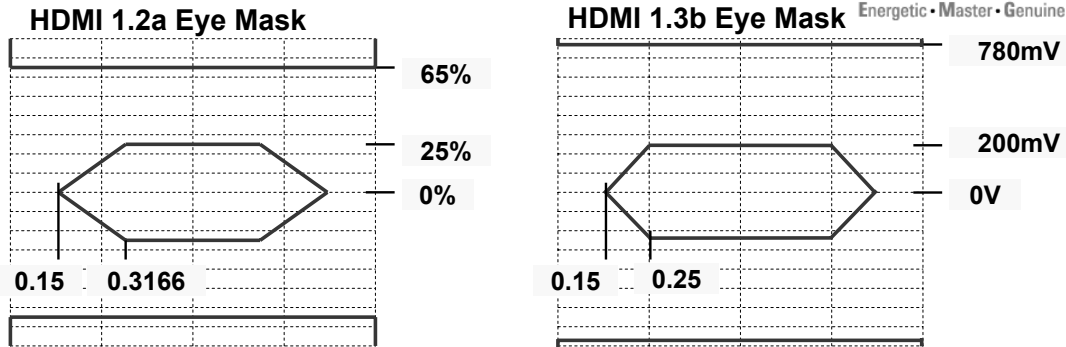
Optimize ROI!



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Change in HDMI 1.3b TP1 Eye Mask



Measurement case of the signal
with amplitude of 800mV
1080p(1.485Gbps)

**The effect of noise
and jitter in the
measurement is
increased**

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Change in HDMI 1.3b

7-4 Transition Time

1.2a: Specification: $75 \leq \text{Transition Time} \leq 4 \cdot T_{bit}$..

1.3b: The specification changed to $75 \leq \text{Transition Time}$.

7-5 Overshoot and Undershoot

Omit test in 1.3 and include for 1.2a selection.

7-6 Inter Pair Skew

Omit clock to data skew test

7-10 Data Eye

1.2a: Normalized Eye with 16 Million points

1.3b: Absolute Eye with 16 Million points.



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Added communication protocol test items of source device

- Addition of Source Advanced Feature measurement
 - Test ID 7-34: Deep Color
 - Test ID 7-35: Gamut Metadata Transmission
 - Test ID 7-36: High Bitrate Audio
 - Test ID 7-37: One Bit Audio
- Above measurement items are supported with Agilent N5998A Protocol Analyzer Generator

Agilent N5998A



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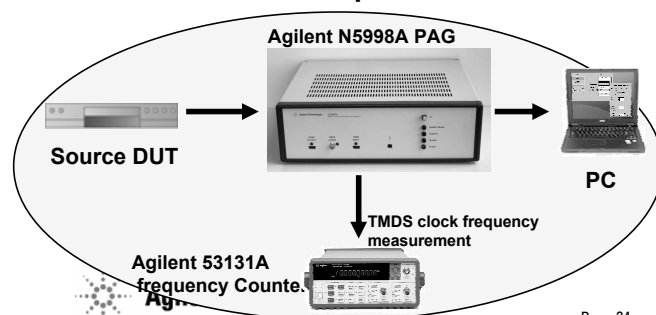
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Communication protocol measurement: protocol analyzer generator

Agilent N5998A Protocol Analyzer Generator

- Equipment recommended in CTS 1.3b
 - Source protocol test: 7-16~7-37 (excluding 7-20~7-22)
 - Sink protocol test: 8-16, 21, 23, 25
- The only possible recommended equipment for Source Advanced Feature protocol test
 - 7-34: Deep Color
 - 7-35: Gamut Metadata Transmission
 - 7-36: High Bitrate Audio
 - 7-37: One Bit Audio
- The capability to output records in form of packet

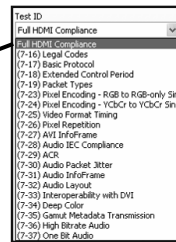
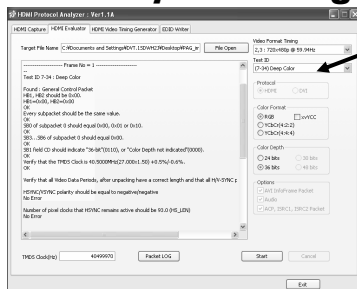
Connection of source protocol measurement



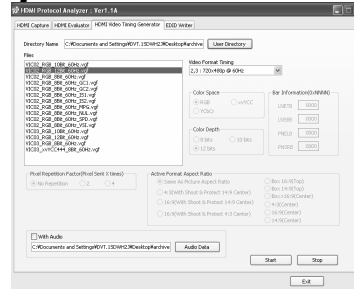
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N5998A communication protocol analyzer and generator displays

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Selection of test ID



Generator output file setup display

Analyzer test display

```
**** Test of xxxx_xxxx.bin ****
**** Date/Time: 20.04.2007(dd.mm.yyyy) / 16:28 ****

----- Frame No = 1 -----
Test ID 7-16 : Legal Codes
Test ID 7-16 : PASS
--
Test ID 7-17 : Basic Protocol
Test ID 7-17 : PASS
--
Test ID 7-18 : Extended Control Period
Test ID 7-18 : PASS
--
Test ID 7-19 : Packet Types
No error: 0/ 0 NULL Packet
No error: 17/ 17 ACR Packet
No error: 1259/ 1259 Audio Sample Packet
No error: 2/ 2 General Control Packet
No error: 0/ 0 ACP Packet
No error: 0/ 0 ISRC1 Packet
```

Test result record output display

```
**** Test of xxx-xxx.bin ****
----- Frame No = 1 -----

# General Control Packet
HB00=0x03, HB01=0x00, HB02=0x00
PB00=0x10, PB01=0x00, PB02=0x00, PB03=0x00, PB04=0x00, PB05=0x00, PB06=0x00
PB07=0x10, PB08=0x00, PB09=0x00, PB10=0x00, PB11=0x00, PB12=0x00, PB13=0x00
PB14=0x10, PB15=0x00, PB16=0x00, PB17=0x00, PB18=0x00, PB19=0x00, PB20=0x00
PB21=0x10, PB22=0x00, PB23=0x00, PB24=0x00, PB25=0x00, PB26=0x00, PB27=0x00
The above General Control Packet starts at 102 pixel in 3 line

# AVI InfoFrame Packet
HB00=0x02, HB01=0x02, HB02=0x0d
PB00=0x01, PB01=0x31, PB02=0x08, PB03=0x00, PB04=0x05, PB05=0x00, PB06=0x00
PB07=0x00, PB08=0x00, PB09=0x00, PB10=0x00, PB11=0x00, PB12=0x00, PB13=0x00
PB14=0x00, PB15=0x00, PB16=0x00, PB17=0x00, PB18=0x00, PB19=0x00, PB20=0x00
PB21=0x00, PB22=0x00, PB23=0x00, PB24=0x00, PB25=0x00, PB26=0x00, PB27=0x00
The above AVI InfoFrame Packet starts at 134 pixel in 3 line

# Audio InfoFrame Packet
HB00=0x04, HB01=0x01, HB02=0x0a
```

Display of output record in form of packet



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